Determining the sensitivity of rivers to abstraction. RAPHSA- a tool for environmental managers

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1. Introduction

A key challenge for environmental managers is the determination of **environmental flows** which allow a maximum yield of water resources to be taken from surface and sub-surface sources, whilst ensuring sufficient water remains in the environment for reliant biota and habitats. It has long been known that some rivers are more sensitive to changes in water levels resulting from river and groundwater abstractions, and hence, less water should be taken from them.

Previously, however, determination of the sensitivity of a river to abstraction has been done on a site-by-site basis (e.g. PHABSIM), which is costly in terms of money and time resources. Here, we outline the development of RAPHSA; a risk-based tool which seeks to **predict relationships between physical habitat and flow** which can then be used to determine the **sensitivity of physical habitat to flow alteration.** RAPHSA makes use of existing (PHABSIM) data, while allowing future and ad hoc data to be incorporated to improve model performance.

2. Project Aims

To produce **generalised habitat vs flow curves** for target species and lifestages (e.g. juvenile salmon; Figure 1) which can then be used at **unmeasured sites** to help inform environment managers of the likely sensitivity of a river/ species to changes in flow due to abstraction.

This poster outlines the work-to-date and future avenues of the **R**apid **A**ssessment of **P**hysical **H**abitat **S**ensitivity to **A**bstraction (**RAPHSA**) project created by the Environment Agency, Centre for Ecology & Hydrology and University of Worcester.

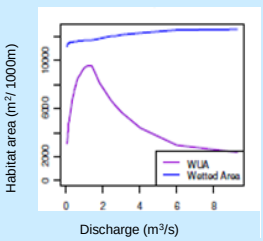

Figure 1: Habitat (weighted useable area & wetted area) vs discharge plot for juvenile salmon [2]

3. Methods (CEH pilot project[1])

- 63 sites (containing 508 cross-sections) from the UK PHABSIM database were extracted (Plate 1)
- 41 flows were simulated for each PHABSIM site ranging from Q_{99} to Q_2
- Cross-section based hydraulic modelling of the PHABSIM transects were used to obtain additional hydraulic property data[1]
- Habitat vs Q curves were calculated using;
  - ❖ Only **physical** catchment variables (BFI, gradient, catchment area)
  - ❖ Physical & **hydrological** catchment variables (annual rainfall, mean flow)
  - ❖ 'Quick' site specific variables (river **width** & max **depth**)
  - ❖ 'Full' site- visit variables (range of **velocity** and depth measurements taken)
- Stepwise multi-linear regression was used to assess the performance of modelled habitat vs Q curves against the full PHABSIM data
- Analysis of modelled relationship between habitat and flow can be used to predict flow- habitat relationships in unmeasured sites
- The slope of the habitat vs Q graph is used to determine the sensitivity of a river to abstraction

Plate 1: Location of PHABSIM sites

4. Results

4.1 Physical variable vs PHABSIM model performance

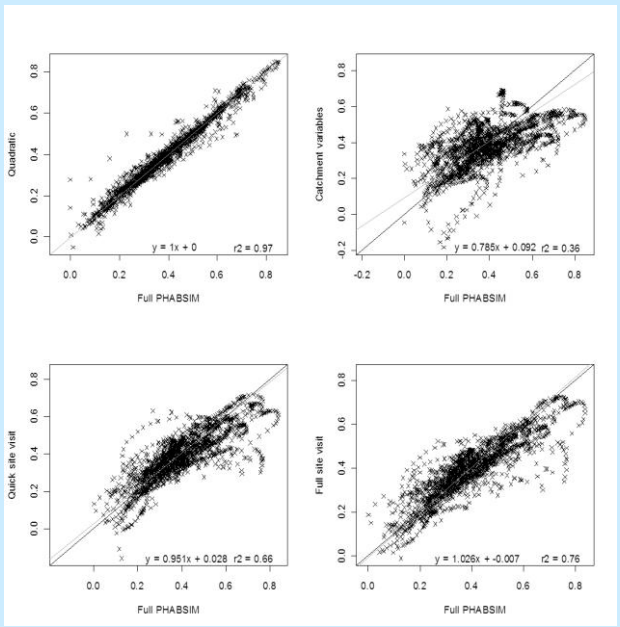

Figure 2: Relationships between modelled vs full PHABSIM habitat models [2]

- A statistically derived quadratic relationship (Figure 2) was found to be the best predictor of the flow- habitat relationship originally defined by the PHABSIM model [2]
- This result suggests that there is a definable relationship between catchment characteristics and habitat for selected target species.
- There is an increase in reliability of model outputs as more information is collected, suggesting that a risk-based approach to resource investment vs model confidence could be further developed

4.2 Sensitivity to abstraction

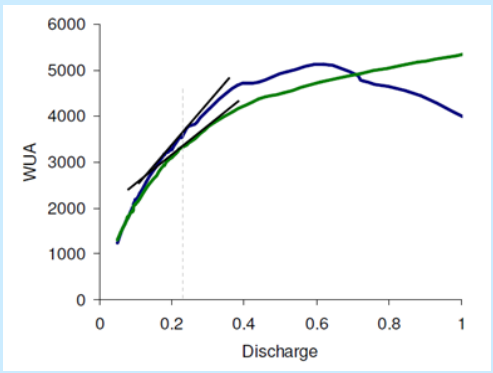

Figure 3: Habitat sensitivity to flow change [2]

- Estimated habitat vs Q models can be devised using existing data to predict unmeasured flow- habitat relationships
- The slope of a habitat vs Q graph indicates the sensitivity of a river to abstraction at that flow.
- The blue line (Fig 3) is **steep**, indicating that the depicted river reach is **more sensitive to abstraction** than the reach depicted by the green line
- Reach/ river/ region/ national models can be created to model perceived river sensitivity to help managers manage environmental flows

5. Further work

- Model validation with field work, collection of additional habitat-flow data and the introduction of regional models are being explored
- Further work is needed to consider how channel modification alters model performance

6. References

(1) Booker, D.J. & Acreman, M.C. (2007). Generalisation of physical habitat- discharge relationships. *HESS* 11(1): 141-157
(2) Acreman, M.C. *et al.* (2006). Rapid assessment of physical habitat sensitivity to abstraction. EA Science Report W6-094/SR